EVALUATION PROGRAM

for

SECONDARY SPACECRAFT CELLS

ACCEPTANCE TEST OF
GULTON INDUSTRIES, INC.
1.25 AMPERE-HOUR NICKEL CADMIUM CELLS
WITH HIGH OVERCHARGE CAPABILITIES

prepared for
GODDARD SPACE FLIGHT CENTER
CONTRACT W11,252B

QUALITY EVALUATION LABORATORY

NAD CRANE, INDIANA

QUALITY EVALUATION LABORATORY
UNITED STATES NAVAL AMMUNITION DEPOT
CRANE, INDIANA

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Enclosure (1)

REPORT BRIEF

GULTON INDUSTRIES, INC. 1.25 AMPERE-HOUR SEALED NICKEL CADMIUM SECONDARY SPACECRAFT CELLS WITH HIGH OVERCHARGE CAPABILITES

Ref: (a) National Aeronautics and Space Administration Purchase Order Number W11,252B
(b) NASA ltr BRA/VBK/pad of 25 September 1961 w/BUWEPS first end FQ-1:WSK of 2 October 1961 to CO NAD Crane
(c) Preliminary Work Statement for Battery Evaluation Program of 25 August 1961

I. TEST ASSIGNMENT BRIEF.

A. In compliance with references (a) and (b), evaluation of Gulton Industries, Inc. 1.25 ampere-hour Secondary Spacecraft Cells with high overcharge capabilities was begun according to the program outline of reference (c).

B. The object of this evaluation program is to gather specific information concerning secondary spacecraft cells. Information concerning performance characteristics and limitations, including cycle life under various electrical and environmental conditions, will be of interest to power systems designers and users. Cell weaknesses, including causes of failure of present designs, will be of interest to suppliers as a guide to product improvement.

C. Twenty-four 1.25 ampere-hour cells (manufacturer's rating) were purchased from Gulton Industries, Inc., Metuchen, New Jersey, by National Aeronautics and Space Administration (NASA). Internally, the cells were designed to have high overcharge capabilities and were supplied in oversize cans.

II. CONCLUSIONS.

A. From the results of this test, it can be concluded that:

1. The ceramic seals of these cells, manufactured by Gulton Industries, Inc., are satisfactory as evidenced by no leakers out of the 24 cells tested.

2. The capacity of the cells was in the acceptable range of 1.33 to 1.80 ampere-hours.

III. RECOMMENDATIONS.

A. It is recommended that these Gulton Industries, Inc. 1.25 ampere-hour cells with high overcharge capabilities be accepted on the basis of the acceptance test results.

RESULTS OF ACCEPTANCE TESTS

OF

1.25 AMPERE-HOUR NICKEL CADMIUM

SECONDARY SPACECRAFT CELLS

MANUFACTURED BY

GULTON INDUSTRIES, INC.

I. INTRODUCTION.

A. On 29 November 1965, this activity began acceptance tests on 24 cells. These tests were completed on 12 January 1966.

II. TEST CONDITIONS.

A. All acceptance tests were performed at an ambient temperature between 23° C and 27° C at existing relative humidity and atmospheric pressure, and consisted of the following:

1. Phenolphthalein Leak Test.
2. Capacity Test.
3. Cell Short Test.
4. Immersion Seal Test.
5. Overcharge Test.
6. Internal Resistance Test.
7. Immersion Seal Test.

B. All charging and discharging was done at constant current (± 5 percent). Cells were charged in series but discharged individually.

III. CELL IDENTIFICATION AND DESCRIPTION.

A. The cells were identified by the manufacturer's serial numbers which were from 101 to 152 although not consecutively.

B. The 1.25 ampere-hour cell is rectangular in shape with an average length, width, and height (base to the top of positive

terminal), of 0.810 inches, 2.095 inches, and 2.752 inches, respectively. The average weight is 522.6 grams, including the pressure gauges and piping. The individual cell dimensions and weights are given in Table I. Figure 1 is a photograph of a Gulton Industries, Inc. 1.25 ampere-hour cell having high overcharge capabilities.

C. The cell container or can is of formed rather than welded construction and is made of cold rolled steel. The cell cover is made of stainless steel. The positive terminal is insulated from the cell cover by a ceramic seal whereas the negative terminal is common to the can. Both terminals protrude through the cover as solder terminals.

D. These cells, rated by the manufacturer at 1.25 ampere-hours, were supplied in a discharged (each with shorting wire) condition.

IV. TEST PROCEDURE AND RESULTS.

A. Phenolphthalein Leak Test:

1. The phenolphthalein leak test is a determination of the condition of the welds and ceramic seal on receipt of the cells. This test was performed with a phenolphthalein spray indicator solution of one-half of one percent concentration.

a. There were no signs of leakage on any of the 24 cells subjected to the leak test.

B. Capacity Test:

1. The capacity test is a determination of the cell capacity at the c/2 discharge rate, where c is the manufacturer's rated capacity, to a cutoff voltage of 1.00 volt per cell. The discharge was made after a 1-hour open circuit period following the 16-hour charge at the c/10 rate. A total of three capacity checks were made at this activity. The cells were discharged individually, but were recharged in series.

2. Since complete capacity data was not submitted by the manufacturer, it was not possible to compare the manufacturer's results with those of this activity. The individual cell capacities ranged from 1.33 to 1.80 ampere-hours for an average of 1.59 ampere-hours to 1.00 volt. The cell capacities together with end of charge and end of discharge pressure readings are tabulated in Table I. Characteristic 2-hour rate discharge curves are shown in Figure 2.

C. Cell Short Test:

1. The cell short test is a means of detecting slight shorting conditions which may exist because of imperfections in the insulating materials or damage to the element in handling or assembly.

2. Following completion of the third capacity discharge test, each individual cell was loaded with a resistor of value giving a c/1 to c/5 discharge rate and allowed to stand 16 hours with the resistor acting as a shorting device. At the end of 16 hours, the resistors were removed and the cells were placed on open circuit stand for 24 hours. Any cell whose voltage did not recover to 1.15 volts or higher was rejected.

3. The open circuit cell voltages, 24 hours after removal of the shorting resistors, ranged from 1.17 to 1.25 volts for an average of 1.22 volts.

4. There were no rejects of any of the cells subjected to the cell short test. The voltage values for the 24 accepted cells are shown in Table I.

D. Immersion Seal Test:

1. The immersion seal test is a means of detecting leakage of a seal or weld. The test was performed before and after the overcharge test sequence to determine the presence and cause of leaks.

2. The cells were placed under water in a bell jar container. A vacuum of 20 inches of mercury was held for 3 minutes. Cells discharging a steady stream of bubbles were considered rejects.

3. There were no rejects in the 24 cells subjected to the immersion seal test.

E. Overcharge Test:

1. The overcharge tests were performed to determine the steady state voltage at specified rates. The test specified a series of constant current charges at c/20, c/10 and c/5 rates, for a minimum of 48 hours at each charge rate or until the increase of the "on-charge" voltage was less than 10 millivolts per day.

2. The cells were monitored hourly throughout the test. Charging was to be discontinued on cells which exceeded 1.50 volts

while on charge or on any cells having internal gas pressure greater than 100 psia. There was no need to remove any cells from the charging sequence.

3. The steady state voltage and internal gas pressure of each cell at the end of each 48-hour charge rate test is shown in Table I. Characteristic overcharge voltage curves are shown in Figure 3.

F. Internal Resistance Test:

1. This test was performed to determine the internal resistance of the cells.

2. At the completion of the overcharge test; the cells were returned to the c/20 charging rate and given a short pulse (5-10 seconds) at a rate of c in amperes. The cell voltages, V1, immediately prior to the pulse, and V2, 5 milliseconds after the pulse, were read on a suitable recording instrument. A CEC high speed oscillograph recorder (28.8 inches of tape per second) was used. The internal resistance of the cell in ohms was calculated according to the following formula:

$$R = \frac{V2 - V1}{Ic - Ic/20}$$

V1 and V2 are in volts, Ic and Ic/20 are in amperes.

3. The internal resistance value for each cell is shown in Table I. The values range from 4.21 to 25.26 milliohms.

TABLE I

CELL NUMBER	TOTAL WEIGHT (GRAMS)	HEIGHT (INCHES)	LENGTH (INCHES)	WIDTH (INCHES)	CAPACITY TEST (A.H.)	CAPACITY TEST (A.H.)	CAPACITY TEST (A.H.)	CELL SHORT TEST (VOLTS)	IMMERSION SEAL TEST	OVERCHARGE c/20	OVERCHARGE c/10	OVERCHARGE c/5	INTERNAL RESISTANCE (MILLIOHMS)	IMMERSION SEAL TEST
101	522.2	2.759	0.808	2.108	1.80	1.51	1.28	1.18	O.K.	1.38 volts -10 psi	1.40 volts -7 psi	1.43 volts 5 psi	4.21	O.K.
106	519.4	2.755	0.813	2.020	1.75	1.49	1.26	1.22	O.K.	1.38 volts -18 psi	1.40 volts -7 psi	1.43 volts 3 psi	8.42	O.K.
109	537.7	2.760	0.810	2.017	1.71	1.50	1.32	1.21	O.K.	1.38 volts -18 psi	1.40 volts -18 psi	1.44 volts -15 psi	4.21	O.K.
116	552.5	2.758	0.812	2.105	1.79	1.46	1.21	1.20	O.K.	1.38 volts -9 psi	1.40 volts -5 psi	1.43 volts 5 psi	8.42	O.K.
117	520.1	2.760	0.804	2.119	1.75	1.50	1.26	1.21	O.K.	1.38 volts -14 psi	1.40 volts -7 psi	1.43 volts 3 psi	25.26	O.K.
131	520.7	2.750	0.808	2.090	1.71	1.38	1.12	1.20	O.K.	1.38 volts -7 psi	1.40 volts 2 psi	1.43 volts 10 psi	4.21	O.K.
132	524.3	2.750	0.812	2.090	1.71	1.35	1.12	1.23	O.K.	1.38 volts -9 psi	1.40 volts -3 psi	1.42 volts 0 psi	8.42	O.K.
134	518.3	2.745	0.810	2.095	1.66	1.35	1.09	1.23	O.K.	1.38 volts -9 psi	1.40 volts -2 psi	1.42 volts 5 psi	4.21	O.K.
135	508.2	2.752	0.814	2.100	1.66	1.35	1.10	1.21	O.K.	1.38 volts -9 psi	1.40 volts 2 psi	1.42 volts 5 psi	8.42	O.K.
136	518.5	2.743	0.808	2.104	1.69	1.44	1.21	1.17	O.K.	1.38 volts -11 psi	1.40 volts -8 psi	1.42 volts 0 psi	8.42	O.K.
137	509.7	2.745	0.812	2.100	1.78	1.55	1.31	1.21	O.K.	1.38 volts -9 psi	1.40 volts -2 psi	1.43 volts 5 psi	8.42	O.K.
138	506.9	2.750	0.810	2.100	1.81	1.53	1.28	1.19	O.K.	1.38 volts -10 psi	1.40 volts 0 psi	1.43 volts 5 psi	8.42	O.K.

TABLE I (Contd)

CELL NUMBER	TOTAL WEIGHT (GRAMS)	HEIGHT (INCHES)	LENGTH (INCHES)	WIDTH (INCHES)	CAPACITY TEST (A.H.)	CAPACITY TEST (A.H.)	CAPACITY TEST (A.H.)	CELL SHORT TEST (VOLTS)	IMMERSION SEAL TEST	OVERCHARGE c/20	OVERCHARGE c/10	OVERCHARGE c/5	INTERNAL RESISTANCE (MILLIOHMS)	IMMERSION SEAL TEST
139	521.2	2.750	0.810	2.105	1.11	1.50	1.03	1.21	O.K.	1.39 volts -5 psi	1.41 volts 1 psi	1.44 volts 11 psi	16.84	O.K.
140	519.7	2.743	0.813	2.103	1.31	1.44	1.24	1.24	O.K.	1.39 volts -13 psi	1.40 volts -4 psi	1.43 volts 1 psi	8.42	O.K.
141	517.4	2.760	0.810	2.100	1.28	1.41	1.25	1.24	O.K.	1.39 volts -10 psi	1.41 volts -3 psi	1.44 volts 5 psi	8.42	O.K.
143	515.3	2.752	0.812	2.100	1.29	1.43	1.21	1.22	O.K.	1.39 volts -9 psi	1.40 volts 0 psi	1.43 volts 9 psi	8.42	O.K.
145	523.4	2.756	0.808	2.100	1.23	1.42	1.25	1.24	O.K.	1.39 volts -5 psi	1.41 volts 2 psi	1.43 volts 11 psi	8.42	O.K.
146	555.7	2.748	0.812	2.110	1.20	1.45	1.24	1.25	O.K.	1.39 volts -2 psi	1.40 volts 6 psi	1.43 volts 12 psi	8.42	O.K.
147	528.0	2.755	0.808	2.096	1.48	1.70	1.53	1.22	O.K.	1.40 volts 2 psi	1.42 volts 0 psi	1.44 volts 3 psi	8.42	O.K.
148	530.0	2.755	0.810	2.105	1.30	1.48	1.33	1.24	O.K.	1.38 volts 0 psi	1.40 volts 5 psi	1.43 volts 16 psi	8.42	O.K.
149	525.6	2.752	0.812	2.095	1.21	1.33	1.22	1.25	O.K.	1.38 volts -5 psi	1.40 volts 2 psi	1.43 volts 11 psi	8.42	O.K.
150	499.0	2.750	0.803	2.105	1.24	1.45	1.41	1.25	O.K.	1.38 volts -8 psi	1.40 volts 3 psi	1.43 volts 11 psi	16.84	O.K.
151	520.9	2.755	0.810	2.100	1.23	1.41	1.23	1.24	O.K.	1.38 volts -9 psi	1.39 volts -2 psi	1.42 volts 4 psi	8.42	O.K.
152	528.0	2.750	0.808	2.112	1.20	1.33	1.19	1.25	O.K.	1.38 volts -5 psi	1.40 volts 0 psi	1.42 volts 8 psi	16.84	O.K.

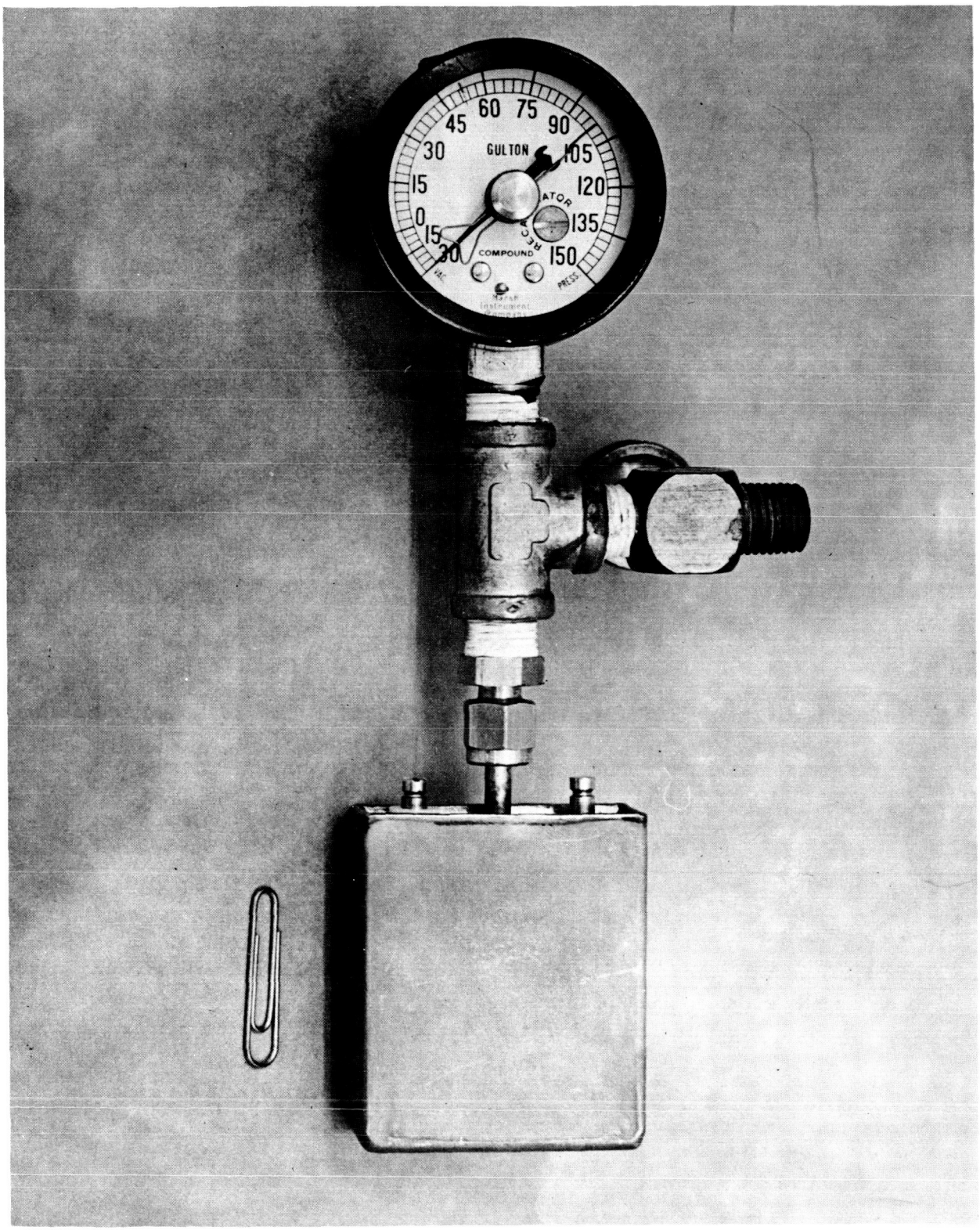
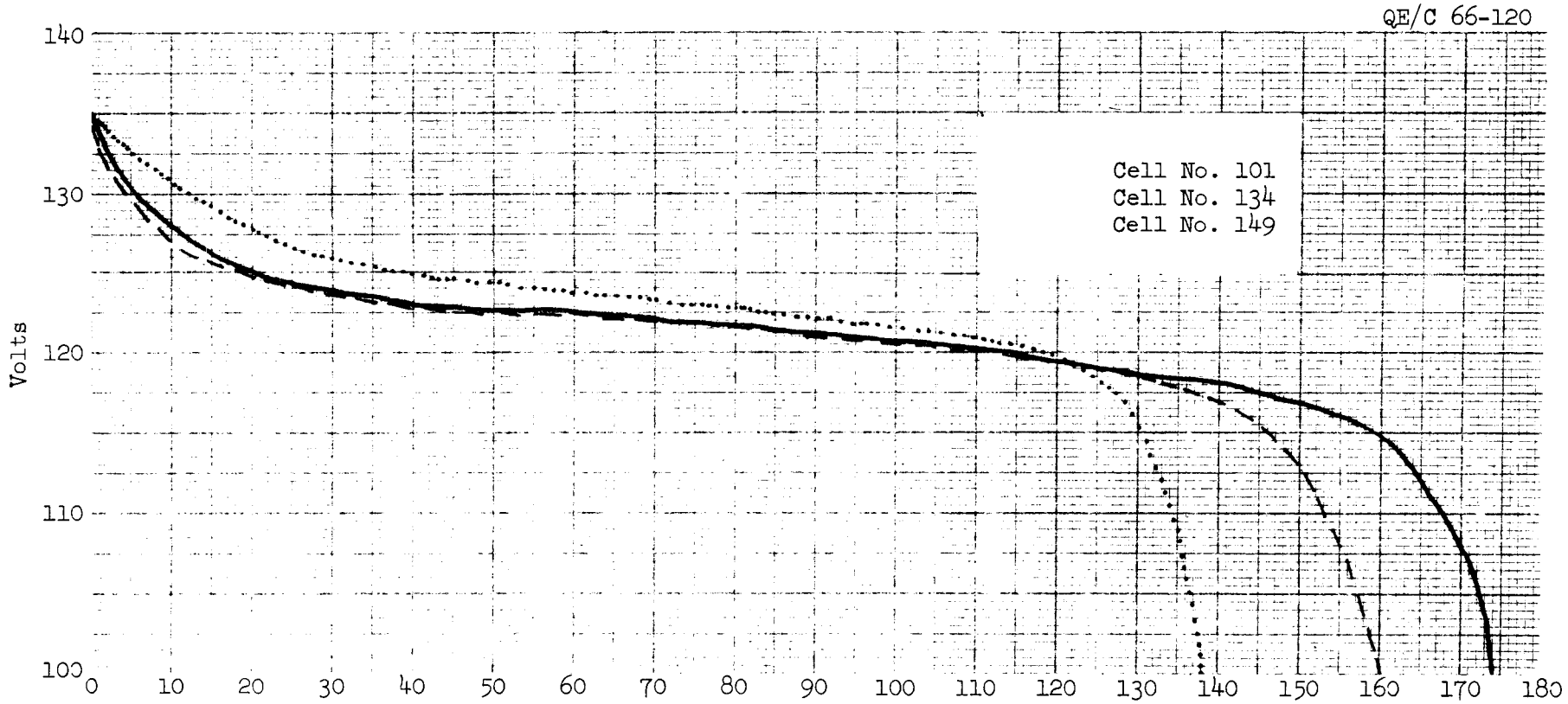
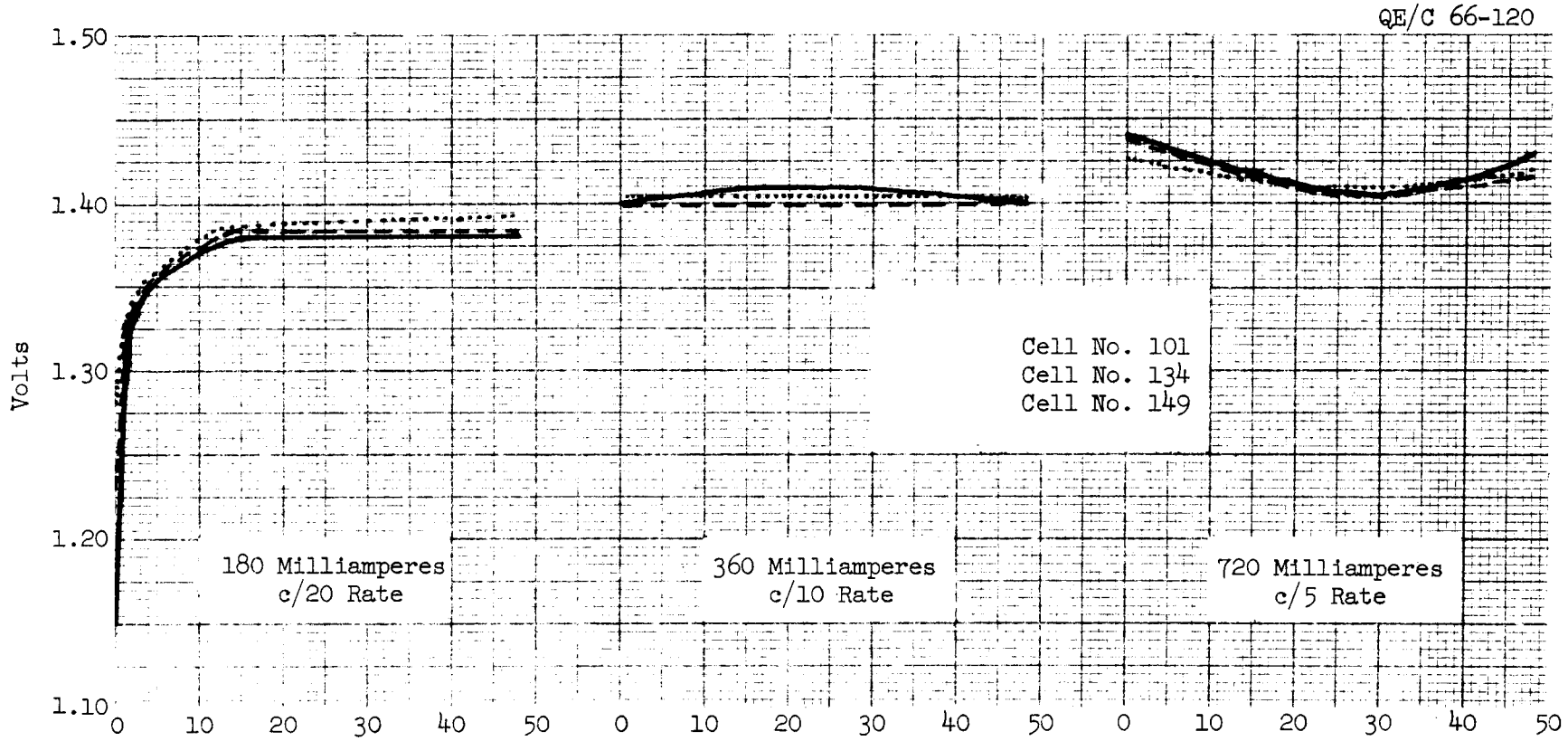


FIGURE 1



CHARACTERISTIC 2-HOUR RATE DISCHARGE CURVES

FIGURE 2



CHARACTERISTIC 48-HOUR OVERCHARGE CURVES

FIGURE 3

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